11:30:02 OCA PAD AMENDMENT - PROJECT HEADER INFORMATION 04/21/94

Active

Project #: E-20-X68 Cost share #: Rev #: 3
Center # : 10/24-6-R7887-0A0 Center shr #: OCA file #:
Work type : RES
Contract#: AGMT DTD 8/11/93 Mod #: LTR OF 4/11/94 Document : AGR
Prime #: Contract entity: GTRC

Subprojects ? : Y CFDA: NA
Main project #: PE #: NA

Project unit: CIVIL ENGR Unit code: 02.010.116
Project director(s):
BARKSDALE R D CIVIL ENGR (404)894-6225

Sponsor/division names: AMERICAN AGGREGATES / XENIA, OH
Sponsor/division codes: 200 / 122

Award period: 930820 to 940501 (performance) 940501 (reports)

Sponsor amount	New this change	Total to date
Contract value	0.00	9,700.00
Funded	0.00	9,700.00
Cost sharing amount		0.00

Does subcontracting plan apply ?: N

Title: AGGREGATE TESTING PROGRAM FOR SOUTHERN AGGREGATES POSTELL QUARRY

PROJECT ADMINISTRATION DATA

OCA contact: William F. Brown 894-4820

Sponsor technical contact

DAVID JAHN
(513)429-0976

AMERICAN AGGREGATES CORPORATION
780 NORTH VALLEY ROAD
XENIA, OH 45385-7125

Sponsor issuing office

DAVID JAHN
(513)429-0976

AMERICAN AGGREGATES CORPORATION
780 NORTH VALLEY ROAD
XENIA, OH 45385-7125

Security class (U,C,S,TS) : U ONR resident rep. is ACO (Y/N): N
Defense priority rating : NA NA supplemental sheet
Equipment title vests with: Sponsor X GIT
NONE PROPOSED
Administrative comments -
MOD. LETTER OF/4/11/94 EXTENDS END DATE TO 5/1/94 WITH NO CHANGE IN FUNDS.

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

NOTICE OF PROJECT CLOSEOUT

Closeout Notice Date 05/19/94

Project No. E-20-X68 Center No. 10/24-6-R7887-0A0

Project Director BARKSDALE R D School/Lab CIVIL ENGR

Sponsor AMERICAN AGGREGATES/XENIA, OH

Contract/Grant No. AGMT DTD 8/11/93 Contract Entity GTRC

Prime Contract No. ______

Title AGGREGATE TESTING PROGRAM FOR SOUTHERN AGGREGATES POSTELL QUARRY

Effective Completion Date 940501 (Performance) 940501 (Reports)

Closeout Actions Required:	Y/N	Date Submitted
Final Invoice or Copy of Final Invoice	Y	
Final Report of Inventions and/or Subcontracts	N	
Government Property Inventory & Related Certificate	N	
Classified Material Certificate	N	
Release and Assignment	N	
Other ______	N	

Comments ______

Subproject Under Main Project No. ______

Continues Project No. ______

Distribution Required:

Project Director	Y
Administrative Network Representative	Y
GTRI Accounting/Grants and Contracts	Y
Procurement/Supply Services	Y
Research Property Managment	Y
Research Security Services	N
Reports Coordinator (OCA)	Y
GTRC	Y
Project File	Y
Other ______	N
______	N

Georgia Tech Research Project E20-X68

Report On

Aggregate Testing For
Southern Aggregate's Postell Quary
Prepared For
American Aggregates Corporation
Xeria, Ohio

By
Richard D. Barksdale, Jorge Alba and Stephen Miller

Georgia Institute of Technology

April 1994

AGGREGATE TESTING FOR SOUTHERN AGGREGATE'S POSTELL QUARRY

INTRODUCTION

The purpose of this study is to compare the physical behavior of normal production aggregate base material (sand equivalent SE= 23) with high specific gravity base material (sand equivalent SE=35) for southern Aggregate's Postell Quarry. This study was sponsored by the American Aggregates Corporation and Southern Aggregates Company. The repeated load triaxial test was used as the primary test method for this comparison. Both resilient modulus and permanent deformation material response was obtained from the repeated load triaxial test performed on the two Postell materials.

REPEATED LOAD TRIAXIAL TESTS

Test procedure

The repeated load triaxial tests were performed using an MTS closed loop electrohydraulic testing system and an Analog Devics analog to digital data acquisition system. The detailed test procedure used for the repeated load tests is given elsewhere [1]. All tests were performed on 6 in. diameter specimens at the as-compacted water content.

Resilient moduli were measured using three approaches: (1) two LVDTs mounted on clamps placed directly on the specimen, (2) two LVDTs placed between the top and bottom platens, and (3) two LVDTs placed on the outside of the triaxial cell. A check calibration of the LVDTs was performed before conducting the tests. Measurement systems were found to be working properly as indicated by good agreement between resilient moduli obtained from the clamp and externally mounted LVDTs.

Two specimens were tested for each gradation and material with the combined test results being presented in this report. An exception to this was that only one specimen was used for the fine gradation for the normal production material (SE=23).

Resilient Modulus Model

Resilient moduli were calculated from the test results using The University of Texas (UT-Austin) resilient modulus model. The UT-Austin model was used rather than the more familiar k=θ model since the UT-Austin model provides a statistically better curve fit of the data. The results from each set of resilient modulus tests were combined, and then a regression analysis was performed to obtain the best fit resilient modulus model.

Material Gradation and Density.

The normal production(SG=23) material was tested at a fine, medium, and coarse gradation as shown in Table 1. The high specific gravity material (SE=35) was tested at only the medium gradation (Table 1). The gradations used were the same as those employed in a research study previously performed on these materials by the Georgia Department of Transportation.

TEST RESULTS

Resilient Modulus Test Results

The resilient modului test results are presented in Table 2. The resilient moduli shown in the table were calculated using the UT-Austin model fitted to the results of each pair of tests (except for the fine gradation SE=23 material). Resilient moduli are compared for both a bulk stress θ of 25psi and 40psi. A range of bulk stress from 25psi to 40psi would be expected to encompass the typical stress states existing in aggregate bases. Also, The 1986 AASHTO Design Guide suggests using a bulk stress of 25psi for the subbase; this value of bulk stress is presently used by some states for design.

Medium gradation- A direct comparison for the SE=23 and SE=35 materials for the medium gradation shows the two materials to have resilient moduli of 37,000psi and 36,300psi, respectively, for θ=25psi and 50,500psi and 46,200psi for θ=40psi. For practical purposes the resilient module of these two materials can be considered the same.

For comparison purposes, the resilint moduli for two bases from other sources are also shown in Table 2. Base 1 is a Norcross quarry base aggregate (1.5 in. maximum size, 100 percent T-180 compaction), and Base 4 is a well graded, 3/4in. maximum size aggregate having a plasticity index of 5 and compacted to 95% T-180 density. Both of these materials have approximately a medium gradation. The resislient moduli for both materials are lower than for either the SE=23 or SE=35 Postell base materials. Based on these and other test results, both Postell materials exhibit above average resilient moduli performance.

Fine and coarse gradation- Resilient moduli for the fine and coarse gradation Postell normal production (SE=23) base materials are also shown in Table 2. For these gradations, the resilient moduli decrease compared to that for the medium gradation. For example, at a bulk stress of θ=25psi, the medium gradation resilient moduli is 37,000psi compared to 24,400psi for the fine gradation and 17,500psi for the coarse gradation.

Resilient moduli were not obtained for either a fine or coarse gradation for the high specific gravity material (SE=35). However, had tests been performed for coarse and fine gradations, the resilient moduli would also be expected to decrease.

Permanent Deformation Test Results

The 1986 AASHTO Design Guide uses resilient modulus in determining the structural coefficient of bases. However, permanent deformation is also considered to be an important design input which should also be included in the design process. Results of permanent deformation tests are also given in Table 2.

Medium Gradation- For the medium gradation, a direct comparison can be made between the normal production (SE=23) and high production (SE=35) materials.The measured permanent strain (ΔE-in percent) obtained after completing the resilient modulus test and applying 50,000 additional load repetitions was 0.043 in./in. for the SE=23 material compared to 0.025 in./in. for the SE=35 material. Both of these permanent strains are quite small. A permanent strain of 0.025 in./in. corresponds, for example, to a permanent specimen deformation of only 0.003 in. at the end of the test.

For comparison, 8 bases having typical gradations had an average permanent strain (in percent) of 0.15 in./in. with a maximum value of 0.20 and a minimum value of 0.114. Therefore, both Postell materials, for a medium gradation, exhibited less permanent strain than the best of the 8 materials tested in the other study.

Table 2 also shows a comparison of permanent strain (E_T) measured throughout the resilient modules test and then for 50,000 additional load repetitions. The medium gradation SE=23 material exhibited less permanent strain than either the Norcross base (Base 1) or Base 4 (0.2 in/in. compared to 0.35 in./in. and 0.26 in./in., respectively).

The permanent deformation performance for a medium grading is somewhat better for the high specific gravity material (SE=35) compared to the normal production material (SE=23). Both materials, for a medium grading, exhibit excellent behavior compared to other typical bases. These results indicate that both the SE=23 and SE=35 materials should exhibit quite good resilient and permanent deformation performance when placed at a grading near the medium curve used in this study.

Coarse and Fine Gradation - The permanent deformation performance (given in percent strain) of the coarse and fine gradations for the complete test (E_t in Table 2) was poorer than for the medium gradation (0.65 in./in. compared to 0.21 in./in. for the medium grading). These results are in agreement with the resilient modulus test findings.

Comparison data for fine and coarse gradations of the SE=35 material is not available. However, an increase in permanent deformation susceptibility would be expected as the gradation moves away from the vicinity of the medium grading.

SUMMARY AND CONCLUSIONS

The resilient moduli of both the normal production (SE=23) and high specific gravity (SE=35) materials are, from a practical viewpoint, the same for a medium grading. Also, these resilient moduli are greater than resilient moduli typically measured for other materials.

As the grading becomes finer and coarser than the medium grading, the normal pruduction (SE=23) material exhibited poorer reslient modulus and permanent deformation performance. Tests were not performed on the high specific gravity material (SE=35), but poorer performance would also be expected for this material. These results suggest that both materials should be placed at a grading in the vicinty of the medium grading curve used in this study. If medium grading is maintained, both the SE=23 and SE=35 materials should exhibit better than average performance when compared to other materials.

REFERENCES

1. Barksdale, et. al., "Laboratory Determination of Resilient Modulus for Flexible Pavement Design - Appendix D", Interim Report No. 2, NCHRP Project 1-28, October, 1993.

TABLE 1. Summary of Repeated Load Test Results: Direct Comparison of SE=23 and SE=35 Material

Material	Resilient Modulus (psi)		Permanent Strain (%)	
	θ=25 psi (2)	θ=40 psi (3)	$\epsilon\Delta$ (4)	ϵ_T (5)
Normal Production (SE=23) Fine Gradation Medium Gradation Coasrse Gradation	 24,400 37,000 17,500	 33,100 50,500 25,000	 0.25 0.043 0.29	 0.65 0.21 0.76
High Specific Gravity (SE = 35) Medium Gradation	 36,300	 46,200	 0.025	 -----------
Comparison Bases (~Medium Gradation) Base 1(Norcross Quarry) (Gravel)	 32,000 29,900	 41,300 39,600	 ---------- ----------	 0.35 0.26

NOTES:

1. Axial Deformation measured using clamps mounted on the specimen; Resilient modulus calculated using U.T-Austin Model and Composite of two test results.

2. For Bulk stressθ=25:

3. For Bulk Stress θ=40psi: σ_d = 17.5 psi and σ_3 = 7.5psi.

4. Permanent deformation for 50,000 load repetitions measured after resilient modulus test. Stress conditions used: σ_3=6psi,σ_1/σ_3=4; Average of two tests.

5. Permanent deformation measured throughout resilient modulus test and then 50,000 repitions atσ_3=6psi and σ_1/σ_3=4; average of two tests.

Table 1. Summary of Aggregate Gradation and Specimen Density Used in Study

Gradation	SE Valve	% Passing							Sieve Analysis: - No 10 [1]					MAX. Density GHD-49 (pcf.)
		1½	1	¾	½	⅜	No.4	No. 10	No. 16	No. 50	No. 60	No. 100	No. 200	
Normal Production Material														
Coarse	23 [2]	100	96	83	67	57	40	28	86	-	55	42	28	144.4
Medium	23 [2]	100	96	85	70	61	45	35	86	-	55	42	28	142.7
Fine	23 [2]	100	96	87	74	66	52	43	86	-	55	42	28	143.8
High Specific Gravity Material														
Medium	35	100	96	85	70	61	45	35	85.4	68	52	42	23.5	143.3

NOTES:

1. Average of two washed tests.
2. Normal Production (SE=23) -No. 10 Sieve material tested was material Georgia DOT had stored in the laboratory;
   Normal Production material obtained fromthe quarry had a SE=26 but was not used.